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TECHNICAL REPORT RD-CR-83-3

BATTLEFIELD SYSTEMS POWER NETWORK OPTIMIZATION
FINAL SUMMARY REPORT

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Prepared for: System Simulation Directorate US Army Missile Laboratory Redstone Arsenal, Alabama



October 1982



# U.S.ARMY MISSILE COMMAND

Redstone Arsenal, Alabama 35898

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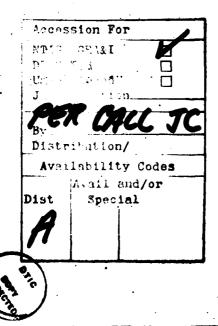
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Our approach was to develop a computer-assisted, interactive decision model which is both portable and user friendly. The computer we chose was the Chromatic Colorgraphics system which both aids in clarifying the problem CONTINUED

## 20. ABSTRACT (continued)

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The decision support system we developed to aid the user in finding solutions to this problem is based on solving the k-best, minimum weight spanning trees for the network. It displays these k-trees in a tabular form which the user can then superimpose on a map and then utilizing any additional information he may possess, decide upon a best solution. The model is easily expandable to larger, more complex situations and is equally useful in non-tactical applications. At the end of the report, we have suggested further possible applications and expansions for this system.





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## **SUMMARY**

This research project studies an alternative system for power distribution in a tactical environment whose goal is to improve overall reliability while reducing the total cost of generating power. As a means of accomplishing this end, we explore the concept of "common users" of generators in order to reduce system down time and optimize generator distribution.

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#### CHAPTER I

#### INTRODUCTION

## A. Background

Continuous technological advances have made the modern battlefield highly sophisticated and lethal. Everything from target acquisition and engagement systems, to communications equipment, to the First Sergeant's coffee pot and electric razor are dependent on some form of electricity to operate. A weapons system capable of engaging multiple targets simultaneously is worthless if we cannot supply it with enough power to remain operational.

A possible solution, the use of commercially produced power, is not feasible. On the one hand, we cannot depend on such a source being available in a wartime environment. Commercial power plants will be prime targets early on in any hostilities. Additionally, today's systems operate on a variety of voltages which further complicates the issue. Finally, more often than not, units can expect to be operating in remote regions where commercial power is unavailable.

The solution has been and still is generators. However, system proliferation and variation have made the types and number of generators a complex, frustrating problem. Looking at the generators required by the Heavy Division 10 the Division 86 studies (see Appendix A-1), one sees everything from .5 kilowatts to 100 kilowatts, 28 volts to 240 volts, 60 hertz to 400 hertz and one phase to three phase generators, in skid-mounted and trailer-mounted configurations. The quantities are staggering. Looking only at the requirements for 60 hertz, 120 volt power generator equipment, one filds the figures displayed in Appendix A-2; a total of 938 generator sets producing 4,943.5 kilowatts of power.

Associated with this vast number of generators are the further requirements for the operators, mechanics, and repair parts necessary to run and maintain these pieces of equipment.

Realizing the inherent difficulties associated with our current system, the U.S. Army Construction Engineering Research Laboratory studied the issues and presented their findings in the <u>Electrical Power Generation Distribution</u> (EGAD) Report in December 1975 [13]. The study essentially recognized the need for systematic optimization of electrical systems and the development of planning, design, and construction capabilities for such systems. Their recomendations were addressed toward non-tactical applications, however, we feel the ideas expressed are compatible with tactical power generation.

Presently, another option which the Corps of Engineers is researching is the possibility of providing a standard family of power generation equipment which through the use of transformers can be adapted to all systems currently found on the battlefield. It is along this vein that this study progresses toward a possible alternative to the existing doctrine.

# B. Purpose of Research

The purpose of this research project is to study an alternative system for power distribution in a tactical environment which improves overall reliability while reducing the total cost of generating power. Additionally, we explore the concept of "common users" of generators as a means of reducing system down time and optimizing generator distribution.

## C. Approach

Our approach was to develop a computer-assisted, interactive decision model which is both portable and user friendly. To aid in clarity and to

enhance the interest of possible users of this system, it was developed on a color-graphics computer system.

Our problem to be studied was this: Given an area of operations, there are x units on the ground at given locations. These locations can be readily identified on a map and are interconnected by a road network. Some number, n, of these units have a need for K kilowatts of power. The cost of providing this power is the distance between the units. What is needed is a system to optimize the location of a "common user" generator or a bank of generators in order to minimize the distances necessary to run power lines.

A PROTOTYPE DECISION

SUPPORT SYSTEM

FOR

POWER DISTRIBUTION

SYSTEMS

Figure 1. - Example of Graphic Display

#### CHAPTER II

#### ASSUMPTIONS AND MATHEMATICAL FORMULATION

## A. Assumptions

In formulating this model, it was necessary to make/impose a number of assumptions:

- (1) The cost of providing "common user" power is proportional to the total distance of transmission lines necessary. It should be noted that whenever two or more nodes are connected by existing power transmission lines, these can be incorporated into the model by assigning those arcs a minimal cost or no cost.
- (2) All needed data is available to the decision maker. Information required is a map of the area, present unit locations, unit demand in kilowatts, existing transmission lines if any, and priority of units in case total demand exceeds total supply.
- (3) There is no additional fixed cost associated with providing power to one site over another.
- (4) Locations and demands are considered to be relatively static. Once a generator location is chosen, it is not expected to have to be moved daily.
- (5) The "common user" generators will be located at a node. That is they will be co-located with one of the demand points. This has intuitive appeal as the operators and maintenance personnel will require rations, fuel, etc.
- (6) That the generator requirements shown in the unit TOE's is necessary to remain fully operational. No attempt was made to try and ascertain how much of each TO&E was safety margin and how much was actually required.

(7) It will be assumed that all transmission lines will run alongside existing roads. This has intuitive appeal in that existing power lines
are most likely to be found along existing road networks. Also, if lines must
be constructed, it would be much easier and quicker to run them along existing
roads.

# B. Mathematical Formulation

The mathematical formulation which comes closest to representing the Power Distribution System problem is the shortest path problem [2]. Consider a network with m nodes and n arcs and a cost C<sub>ij</sub> associated with each arc in the network. The shortest path problem is: Find the shortest (least costly) path from node 1 to node m in the network. The cost of the path is the sum of the costs on the arcs in the path.

To formulate the problem, set up a network in which we wish to send a single unit of flow from node 1 to node m at minimal cost. Thus  $b_1 = 1$ ,  $b_m = -1$ ,  $b_i = \emptyset$  for  $i \neq 1$  or m. The mathematical formulation comes from [2], page 483:

Minimize 
$$\sum_{i=1}^{m} \sum_{i=1}^{m} C_{ij} X_{ij}$$
Subject to 
$$\sum_{j=1}^{m} X_{ij} - \sum_{k=1}^{m} X_{ki} = \begin{cases} 1 & \text{if } i = 1 \\ \emptyset & \text{if } i \neq 1 \text{ or } m \\ -1 & \text{if } i = m \end{cases}$$

$$X_{ij} = \emptyset \text{ or } 1 \text{ for } i, j = 1, 2, \dots, m$$

The constraints  $X_{ij} = \emptyset$  or 1 indicates that each arc is either in the path or not.

In order to solve this problem, we have utilized an algorithm to find k minimum weight spanning trees for the newtork. The user determines the value of k, the number of minimum weight spanning trees he wishes to see, up to five. That is, the algorithm will select the spanning tree with the least cost, the second smallest cost, etc. until it has found the five best solutions.

A spanning tree is a nondirected tree defined as follows [6]:

- (i) A connected graph of n vertices and (n-1) links
- or (ii) A connected graph without a circuit

or (iii) A graph in which every pair of vertices is connected with one and only one elementary path.

The minimum weight or shortest spanning tree is that nondirected tree which minimizes the sum of the arcs. The shortest spanning tree of a graph has obvious applications in cases where roads (gas pipelines, electric power lines, etc.) are to be used to connect n points together in such a way so as to minimize the total length of road that has to be constructed [6, pp. 124-125].

## C. The K Tree Algorithm

The algorithm implemented used the general approach suggested in Gabow's paper, "Two Algorithms for Generating Weighted Spanning Trees in Order" [24, pp. 140-147]. It utilized a three phase approach.

Step 1. The first step formed the minimum weight spanning tree by Prim's method [24, pp. 138-139]. This algorithm produces the shortest spanning tree by growing one subtree  $T_S$  containing more than a single vertex and considering the remaining vertices to form one subtree each. Subtree  $T_S$  is then grown continuously by adjoining that link  $(X_{ij})$ ,  $X_i \in T_S$ ,  $X_j \in T_S$  with the minimum cost  $C_{ij}$  until (n-1) links are added and  $T_S$  becomes the required shortest spanning tree. This step is incorporated in lines 6500-6799 of Program SOLV Appendix C).

Step 2 Step 2 found the minimum weight exchange link subject to a set of membership constraints. A link,  $X_{ij}$ , not a member of spanning tree K, is eligible to enter and replace link  $X_{i,k}$ , an existing member of the spanning tree, provided link  $X_{ij}$  is not restricted from entering and link  $X_{i,k}$  is not

restricted from leaving. The minimum cost replacement for all candidate entering/departing link combinations is selected. This is accomplished by lines 6800-6990 of Program SOLVE (Appendix C).

Step 3. The minimum cost new spanning tree is selected from all candidate new trees. Two disjoint sets of restrictions are generated:

- (i) The parent tree has the restriction imposed that existing arc must be retained for all future candidate spanning trees generated from the parent (in addition to any previously imposed restrictions).
- (ii) The offspring tree has the restriction imposed that the existing link may not enter any future candidate trees generated from this tree (in addition to any previously imposed restrictions on the parent tree).

This step is implemented by lines 6155-6165 of Program SOLVE (Appendix C).

## CHAPTER III

#### THE DECISION MAKING PROCEDURE

# A. Existing System

The existing decision making process for location of generators can be summarized as follows:

- (1) Following established rules and regulations, the organization divisions of the directorate of Combat Developments allocates generators of various types to each unit according to their equipment requirements and power needs.
- (2) Built into these figures are certain allowances for extra generators in case the primary means of power becomes nonoperational.
- (3) In a field environment, as generators are lost through mechanical vailure or battlefield losses, the unit commander shifts his assets according to his own established priorities.
- (4) If he should reach a point whereby he is no longer capable of accomplishing his mission, the unit commander requests additional support from his superior organization.
- (5) If no additional power genration equipment is available, the unit becomes ineffective.

## B. Proposed System

The Decision Support System we propose would modify this as follows:

(1) When writing the TOE's, the developers should only meet the unit's base requirements and not add all the "additional" or "safety factor" generators.

- (2) In the field environment, the location of each unit requiring additional power is plotted on a scaled map no larger than eleven inches by eleven inches. This map is taped to the BITPAD, input into the computer, and stored on a disk according to the directions given by the program NTRACE. (If the network is already on disk, that disk is mounted on disk drive #2.)
- (3) The decision maker knows the power requirements of each unit, the unit's priority and through some means of reporting such as readiness reports, he knows how many generators are down. He also knows how much "common user" capability is available to supply those units which are in need.
- (4) If the supply cannot meet the demand, he must reduce or eliminate units according to his priorities until such time as the demand can be met.
- (5) Once he has determined that his supply is adequate to meet his demand, he utilizes the program <u>SOLVE</u> to produce up to the five best possible routes to take to supply the needed power.
- (6) Here is where the decision maker interacts with the computed solutions. He can take the five (or however many he requested) best solutions and lay them out on his map to select the best solution. The human is capable of looking at the terrain, obstacles, the present tactical situation, anticipated actions, etc., and taking this knowledge into account, select the best solution.
- (7) Onec the decision has been made, the units are connected to the "common" source and the system is monitored and changes are made as needed by following the same procedure.
- (8) The user also selects the best location for the power plant(s). Again, utilizing the map and his knowledge of the units located at each point, he is able to select that unit which is best able to support the power plant and co-locates his teams with them. Due to the nature of power distribution this can be any of the points in the network. It does not have to be at the

median or center. Again, here is where the interaction between the user and the computer becomes valuable. Figure 2 depicts a flowchart of user actions.

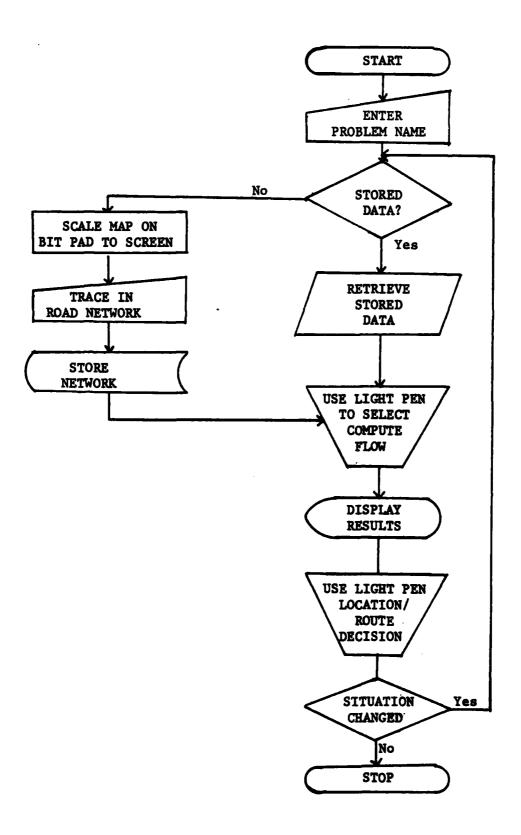


Figure 2. Flowchart of User Actions

#### CHAPTER IV

#### IMPLEMENTATION AND DOCUMENTATION

# A. Instrumentation and Equipment

The primary item of equipment utilized in this model is the Chromatics color graphics minicomputer [32]. It is a wholly self-contained, high resolution (512 by 512 dot matrix) color graphics terminal with an integral Z-80 microprocessor, attached floppy disk drives and 64 k bytes of random access memory. It's high resolution screen provides a choice of from one to eight colors and automatically generates geometric figures as well as graphs and bar charts.

As an additional feature, the terminal is equipped with a light pen.

This is a device which is capable of detecting light on the screen and relaying a signal back to the terminal. This signal is then used to pinpoint the location of the light pen relative to the screen. This is the primary device for controlling program execution.

A digitizer pad is utilized to input the nodes and arcs into the computer while displaying a visual representation of the network on the screen. This accessory to the terminal converts graphic information into a digital form suitable for use by the Z-80 microprocessor. It is operated by positioning the crosshairs or touching a stylus to any position on a map which is affixed to the pad's surface. The x,y coordinates of that position are then transformed into their digital equivalents and transmitted to the terminal for processing.

# B. Implementation and Documentation

All programming was accomplished using Chromatics Basic Language [7]. The primary blocks are: (i) map data input, (ii) menu selection control, (iii) general purpose data input, (iv) data manipulation, (v) computations execution and (vi) display of the results.

The program NTRACE is a modification of Monte Anderson's [1] program which he used for his thesis work. It is used primarily to trace in the networks and control the switching to the program SOLVE. The similarity between this model and the Water Point Model created by Cpt. Anderson constitutes the beginnings of a library of decision support systems which could be available to a Division Engineer to improve his support and assessment capabilities. NTRACE provides light pen selection of menu items to add nodes or arcs, stop program execution, save data, restart, or solve the problem which has been input into the system. A selection of menu items COMPUTE FLOW or DISPLAY ANALYSIS while under the control of program NTRACE results in all accumulated data being saved on disk automatically and program SOLVE being retrieved from the disk and execution initiated.

Program solve performs all calculations and controls the display of the results. The results of the calculations are not saved on the disk. Both programs were designed to be as user friendly as possible. The procedure for tracing a network is accompanied by detailed instruction to provide a step-by-step routine. The intent is to make it possible to operate the entire program with no background as to what the correct solution procedure should be. For further documentation of the program NTRACE, see Monte Anderson's Master's Thesis [1].

The program <u>SOLVE</u> is even easier to use than <u>NTRACE</u>. <u>SOLVE</u> first explains to the user that it can handle up to sixty nodes and asks the user to type in the number of nodes in his network. This accomplished, it then explains that no node can have more than twenty arcs incident to that node and prompts the user to input the maximum number of arcs incident to any node in the networks.

Next, <u>SOLVE</u> explains that the maximum number of arcs that memory will allow is

SOLVE now has all the data necessary to begin to solve the k minimum weight spanning tree problem. Finally, it asks the user how many trees he would

like to see (5 or less). Once this value is input, the problem is solved for the stated number of minimum weight trees as explained in Chapter II and the results are displayed in tabluar form.

## CHAPTER V

## TEST PROBLEM AND RESULTS

## A. Test Problem

In order to demonstrate the procedure, consider the network shown in Figure 3. It depicts the locations of eight units requiring addition power and the road network which connects them. It has been entered on the BITPAD using the program NTRACE.

The corresponding costs associated with the twelve arcs are shown in

Table 1. The proper procedure for inputing this network is first to input the

Arc	Starting-Ending Node	Costs
1	1-2	4
2	1-3	6
3	1-4	3
4	2-4	2
5	4–5	5
6	3–5	2
7	4-6	5
8	2-6	4
9	5-8	6
10	4-8	6
11	7-8	3
12	6-7	2
	- ·	_

Table 1. Arcs With Associated Costs

eight nodes in order. Each time the blue button is depressed, it will increment the node counter by one. Then, beginning with node number 1, input arc number 1 by touching the cursor to node one, depressing the green button and tracing the road to node number 2. The computer will automatically record the arc number, the beginning and ending nodes, and will computer the cost (distance) of the arc traced. The entire network was input in this manner an is now ready to be solved by switching control to program SOLVE.

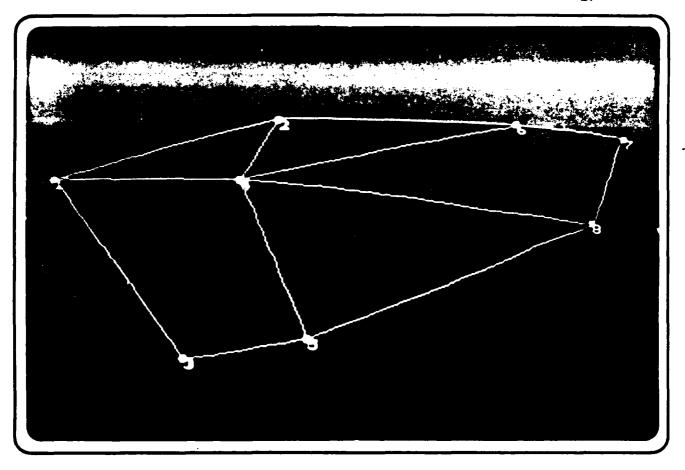


Figure 3. Test Network

# B. Results

The test problem was solved for the five best minimum weight spanning trees and the results as they actually appeared on the cathode ray tube of the chromatics colorgraphics terminal are shown in Tables 2 and 3. At this point the decision maker has all the necessary information to make his selection of the best possible location(s) for his "common user" generators. He takes the five best solutions and plots them on his map. Then, utilizing his knowledge of the situation as well as the previously discussed variables, he selects his site. The five best possible solutions for the test problem are shown as Figures 4 through 8.

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·	SP ARC	NODE#1	NODE#2	COST	ARC #	
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				29		

Table 2. Test Results for k = 1,2,3.

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6 8 11 12			5 2 7 6	**
1 3 5 6 8		1 4		# ************************************

Table 3. Test Results for k = 4,5.

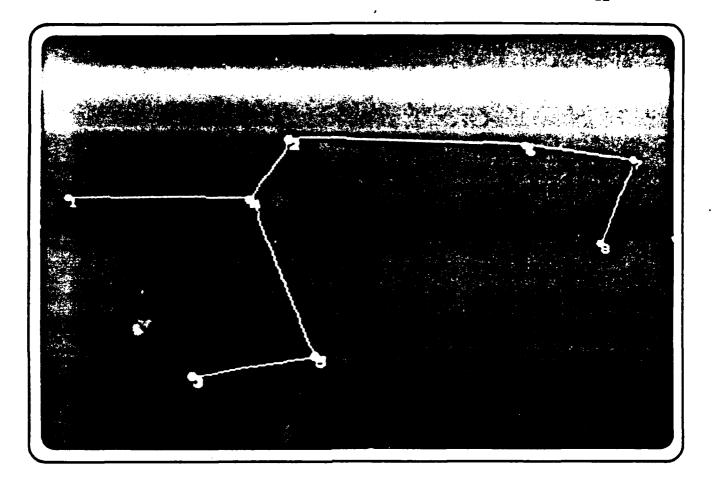


Figure 4. Resulting Network for k = 1.

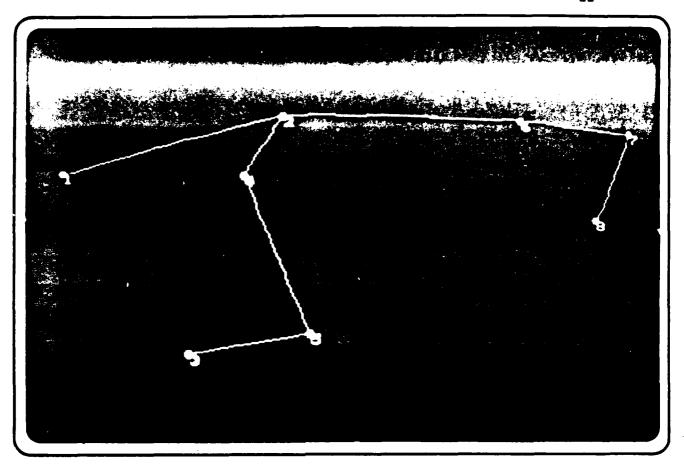


Figure 5. Resulting Network for k = 2.

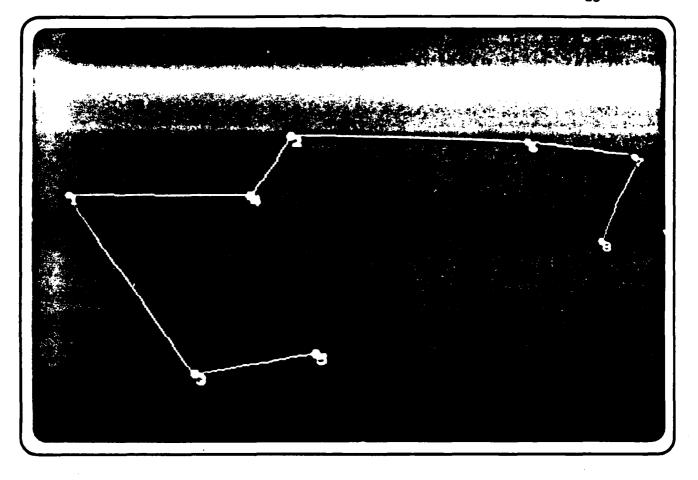


Figure 6. Resulting Network for k = 3.

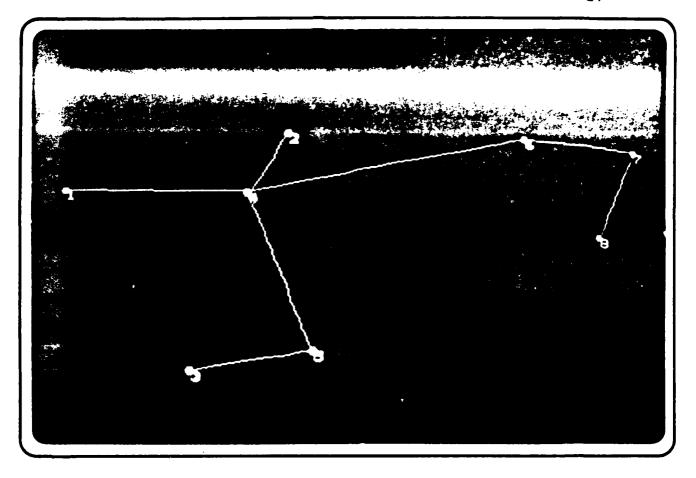


Figure 7. Resulting Network for k = 4.

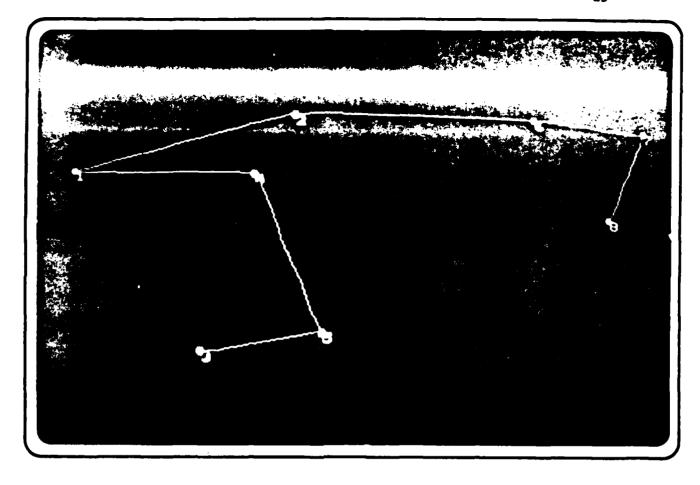


Figure 8. Resulting Network for k = 5.

#### CHAPTER VI

#### CONCLUSIONS AND RECOMMENDATIONS

## A. Conclusions

We realize that this is quite a departure from conventional thinking as far as power distribution systems are concerned. As this concept is delved into further, it may result in the conclusion that this is impractical and inveasible in a constantly moving tactical environment, particularly the closer the units are to the front. However, it should be noted that the idea of "common users" of generators and "power plant teams" is not new in a non-tactical situation.

The Corps of Engineers has both power plant operation and maintenance, and power line teams. These are depicted in Appendices D-1 and D-2. Their concept and mission would be particularly suited to the decision support system described here.

Although this system was originally designed with Division 86 units and their requirements in mind, it is easily extrapolated to Corps and Theater Army levels with only minimal effort. Possibly once you get as high as theater level, you may exceed the memory capability of the Z-80 microprocessor. There are processors available with greater memory capabilite and so this thinking need not be limited by the computer hardware.

Another application of this system would be with the concept of cellular division and corps headquarters. The thought here is that a division headquarters would occupy an area roughly 10 kilometers square (Corps, 15 kilometers). Within this area the various headquarters elements, although dispersed, could be connected by transmission lines to a common source of power. The optimum location of the power plant(s) could easily be determined by our decision support system.

Another concept which the Corps of Engineers is researching is that of power conditioners. As mentioned earlier, there are numerous different sizes, voltages and cycles of power generation equipment in a given unit. When an item requires, say 6 kilowatts to operate, it must use a 10 kilowatt generator (the next larger size). When you multiply this by the number of that piece of equipment in the unit, the excess power becomes even larger. Now expand that over all other items and you'll find there exists a significant overkill.

A power conditioner is a "black box" which can convert cycles, voltages, etc. so that a common source of power can drive any of the diverse systems and thereby reduce the numbers of generator, operator, repair parts, and overall cost to the system. Here again would be an excellent situation where our decision support system could be utilized.

These are but a few possible applications of our system. The possibilities are many and varied.

## B. Recommendations

- (1) We recommend that this area be further explored to determine possible expanded applications of the process considered here. Military pipeline systems would be readily adaptable to such a decision system.
- (2) Time and manpower precluded making this system any more sophisticated than presented here but there are several improvements which could be made to increase it's value.
- (a) The minimum operating power requirements for each unit could be stored in computer memory. The user could take readiness and casualty/damage reports and constantly monitor each unit's present status. Thus shortages would be detected sooner to reduce system down time.
- (b) Voltage losses through transmission lines could be calculated by inputing formulas to account for drops due to distances and wire sizes.

(c) Priority for each unit could be stored in computer memory thus eliminating the need for the user to manually monitor these.

# APPENDIX A

GENERATOR REQUIREMENTS FOR DIVISION 86 UNITS

Appendix A-1.

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-	<u>ا</u>	1	E	•	=	IN W353	367-0d								~
<	5	_ 1	- 1		2	71	120/2404	TAC UIT				10	2		2
CASASS A GEN		FREE		348 5842 1-3F 18KW 6847 1-3F	E E	120/508	120/2404	120/240V 1AC UTIL	. =			12 12	12		
	<u> </u>	1		E	-	10770R 24	1267768 240741AV SONZ TAC UTIL	SOWE TAC	THE					١	
J36383 A BEN	5		_	<b>40HZ</b>	MT ON	1 4-200A1	1 PU-406						•	<b>10</b>	R.
-	5	1	3	2/021		16 VOIST	ZHUOY Hd	THE PRECISE	135						
	5	_ [	- 1		NC C.	7	1 00-451					2			2
137245 # 6EM	25 25			HOE CHOS MAGE	- - -	**************************************	164-04 1	11 5047 TAC U	1111						
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⋖	51		Ë	BOKW GOHZ	Hdt-1	AC 120/2	240 120/208V	_	PU-619/M			72 72	27 5		57
JAZIOS H BEN	ST BAS	L.	E	TOKE BOHZ	1-194	102/021 21	12077071 032	HEDE AREA	PU-KI97M			,			<b> </b>
•	21		_	-	1 7C 1	120/2404	SHOCK		ווווא		,			_	-
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<	5	1		<b>60H7</b>	2	٧	_ 1	TAC	UTILITY	•	129	6 129	120	i	123
	2	i		dI ZM89	MIA C M	1	Ξ.	LINC DIJETIN	וניווג		561				261
<b>4</b>	21	- 1		BC 28V	SHOCK	TACTICAL		,			7	73 71	7		0
	5 !				Ĕ,				74.			1	181		
MACAN A BEN	ST DAS			desi daga	7/07		VEDBY SKIP	=		.					- 1
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J45836 B 6EN	ST BAS	1	1	SKE SEEM? 1-3	PH AC	120/208/2408	7240V TAC					1	Ť		•
⋖	ST GAS			>	0	TOLR FRA	FRAME MTD TAC	FAC UTILITY	Ţ		N	27 27			2.
8	ST BAS	S ENB	F	DG 284 SK	DecHIR		FRENE MTO	TAC UTILITY	E						
<	21	- 1		_ 1		1	01 PU-625	2				54 50	45		20
	7						529-D4 IO								- •
NAD A SEN	7	- 1		- 1	C 410		119-DA 10								
Jebsyc A ben	ST BAS		Ě	J THE SAY	EA MID ON		450-04 E	× 11 11 11 11 11 11 11 11 11 11 11 11 11							
•	,	1	3	DA COU FOR		SHOCK MID		- 1							_
			3	100		120/246 1	**************************************	, •	intri						
•	5	- 1	-1	<b>50HZ</b>		L.042/02	12072figy	SKO TAC							
U	5			2H09	7	20/240	120/2067	TAC	UTIL			~			~
¥	ST 6A	S ENG	H	5KW 60CY 1	Y HOE-	C 120 24	VR057051 04	N/819-04 AH	18/18						-
<b>4</b>	ST			- 1	EA MTO	ON #116	6 PU-420				•	60 79			73
8	Į,	_	Ē	Ē		DI LM MO	024-Dd 9						Ì		2
<	51	1	SKE	0H2	PH AC	120/240	120/208	SKD TAC	שוו		-	10 10	2		2
	ST GAS		765	0	12 A	T. MTD.						~			
CANGOO M GEN	ST GA	S ENG!		2 20 7	₹ > c	L MTO		I				•			_
< q	ST GA		1207	C-1 7400		120/240	750//071	740	UTT. 117		7				12
e •	10	, ,	•	C-1 7400 F	ن و	160/64	1 A90//021 0+2/02	ن ي							
	7	MAS ENG				٦٢	27021 043	2							
C (C	- K		Ë	<b>50HZ</b>			70-132 PU-132					• <b>-</b>	· -		• -

Appendix A-2
Unit Generator Requirements

	.5	1.5	3	5	10	15	30	45	60	100	TOTAL
1/1 Armor		3	1								7.5
2/1 Armor		3	1								7.5
3/1 Mech		8									12.0
1/2 Armor		3 3	1								7.5
2/2 Armor		3	1								7.5
3/2 Mech		8									12.0
1/3 Armor		3 3 8	1								7.5
2/3 Armor		3	1								7.5
3/3 Mech		8									12.0
4/3 Mech		8	_								12.0
Engr. Bn		13	16								64.5
Mil Intel Bn		5		41	12	1					347.5
Signal Bn		8	136	82	7						900.0
MP Company		3									4.5
NBC Company		5									7.5
HHC 1st Bde		4	2	4							32.0
HHC 2nd Bde		4	2	4							32.0
HHC 3rd Bde		4	2	4							32.0
ADA Bn		50	1								78.0
HHB, Divarty		6		24	3						159.0
TGT Aqn Bty		3									4.5
1st Bn, 155 mm		12	1	4							41.0
2nd Bn, 155 mm		12	1	4							41.0
3rd Bn, 155 mm		12	1	4							41.0
8 inch Bn		8									32.0
HHT, ACAB		7		6							40.5
SBT SPT AVN BN	1	28	11	7	2				3		310.5
CAV. SQDN.	1	6		2							19.0
1st Atk Bn		6		4	2 2						49.0
2nd Atk Bn		6		4	2						49.0
HHC STP CMD						4				2	260.0
DMMC, SPT CMD				3		7					120.0
AG Co.		2	1			3					51.0
MED Bn.		3	1		7						77.5
Maint Bn		22	12	8	19	2	3	9	1		884.0
S&T Bn		3	1	6	5	_					87.5
1st Bde Spt Bn		16		7	18	4	1				329.0
2nd Bde Spt Bn		16		7	18	4	1				329.0
3rd Bde Spt Bn		18		7	19	4	1				342.0
HHC, Dvy Div.		2	1	4		4					86.0
	1	334	195	240	114	33	6	9	4	2	4943.5

TOTAL NUMBER 60 HZ, 120 V Generators = 938

APPENDIX B

PROGRAM NTRACE

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NEW COST MATRIX
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     'NN(7).NN(8): # OF SGURCES AND SINKS IN PROBLETINN(8).NN(10).NN(15)=CONSTANT VALUESFROM SUBROUTINE 2600
                                                                                                                                                                                                                                                                                                                                                                                                                                                   'INITIALIZE VARIABLES IF NOT CHAINED FROM COMPUTE
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       IF LENGAS.=0 THEN 100
GIN NN(30)
WAN(30)
WAN(30)-WCTIML # OF NUTES IN PROBLEM;NN(15)=MAXIMUM # OF NODES ALLOWED IN PROBLEM; NN(13)=FLAG FOR
                                                                                                                                                                                                                                                                                                                                          CHANGE SUPPLY/DEMAND IF CHAINED FROM COMPUTE
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             'MN(1),NN(4),NN(2),NN(5)=LOWER LEFT AND UPPER RIGHT XBY BITPAD SCALING POINT COORD RESPECTIVELY
                                                                                                                                                                                                                                                                                                                                                                           'MINOR RESTART IF CHAINED FROM COMPUTE 'MAJOR RESTART IF CHAINED FROM COMPUTE
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            'INPUT CONSTANT VALUES FOR NEW PROBLEM
                                                                                                                                                                                                                                                                  PGINT CHR4(27);"RIC"ICMR4(27);"OES";CHR4(27);"IES";'ESTABLISH COMMUNICATIONS WITH BITPAD
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    :
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             "TOUCH LOWER LEFT SCALE POINT WITH STYLUS OR DEPRESS ANY BUTTON ON THE CURSOR"
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           INPUTATIX, Y, FE: IF FEE" I" OR FEE" GR FEE" 4" OR FEE" B" THEN NN(1) = X:NN(4) = Y ELSE 530
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            CHRELESTE TESTIFF TO SCHOOL NEED BONDED AND THORK FOR STORAGE IN DISK FILE: "CA
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          'GKIP ALL INSTRUCTIONS IF 56<>"Y
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 BITPAD AND SECURE IT IN PLACE
LEFT CORNER AND UPPER ";
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               PRINT"HITH THE. IDENTIFY H POINT IN BOTH THE LOWER LEFT CORNER AND UPPER "; PRINT"RIGHT CORNER THAT IS NO MORE THAN 1/4 INCH OUTSIDE BOTH THE X AND Y AXIS "; PRINT"BOUNDRIES OF THE IDENTIFIED AREA. "
PRINT CHRESTO'S" "XOCZ" VGCZ" CETHESE TWO POINTS MILL BE USED BY ";
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                TRANSP ALGORITHE
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           "AFTER IT IS CENTERED ON THE SCALE POINT. LISTEN FOR A BELL."WOO1255"CS" "IF YOU DO NOT NEAR A BELL THEN YOU ARE GUTSIDE OF THE SENSITIVE AREA"
ON A ROAD NETHORK
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              SUPPLY/DEMAND SHORTEST PATH
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   MUST BE NO MORE THAN 10 INCHES BY 10 " !
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     LEFTW(ZW,1; **Y** THEN GUSUB 2700:GOSUB 660:GOTO 1000 'RETRIEVE STORED DATA
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  ne input"-cshit return when you are rendy to begin. "c7"6+0,0,0111.811";24
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      PRINT CHRELLOSS "CIDO YOU WANT INSTRUCTIONS: "CS"IYES=Y OR NO=N"2"C1"J ";
LINE INPUT SELIF LEFTE(Se.1).<>"THEN 480
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 ARRAYS FOR GRAPHING
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          "ON THE BITPHD. DECREMEE THE SIZE OF THE MACH TO BE TRACED.
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             CULT ARRAYS
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                ARRAYS FOR
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              ARRAYS FOR
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               ARRAYS FOR
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    'NN(3),NN(6)*COMPUTED XAY SCALING CONSTANTS FROM ABOVE VALUES
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            PRINT"YOU SHOULD NOW PRÉPARE TO ENTER THE DESIRED NETHORK.";
PRINT"THE AREA ON THE MAP OF CONCERN MUST BE NO HORE THAN
                                                *** PROTOTYPE DECISION SUPPORT SYSTEM FOR WAREHOUSE LOCATION ***FOR BOCUMENTATION SEE MASTERS THESIS BY MONTY J. HNDERSON, ***GEORGIA INSTITUTE OF TECH., PROF DONOVAN YOUNG, CHAIRMAN
                                                                                                                                                                                                                                                                                                                                                                           'HINDR
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       Yes=Y or no=N "C5";Z$
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               INT.YOU TO SCALE THE BIZE OF THE IDENTIFIED ";
INT.AREA TO THE FULL BIZE OF THE SCREEN."
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 INT"INCHES. CENTER THE IDENTIFIED AREA ON THE
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      PRINT"IS THERE DATA PRESENTLY STORED UNDER NAME:
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      -C3-:A0
                                                                                                                                                                                                                                                                                                                                          660:60TO 4300
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   EIM ALCIODI, AZ(100), DEG(60), NARC(60, 20), C(100)
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   BIM ID(1), MF(1), NB(1), MA(1), NU(1), IU(1), ZP(1)
                                                                                                                                                         ". MODIFIED BY CPT ROBERT L. ENVIS. HPRIL 1982
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             DX(1,1), NX(1), NY(1), NG(1), NT(1), AL(1)
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      LINE INPUT"(For Disk Storess of Data):
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        PRINT CHR0(12); ""U001500"C4"; CHR0(7);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        PRINT" FOLLOW TRACING INSTRUCTIONS"
                                                                                                                                                                                                                                                                                                                                          F 31 AND 82 THEN 81-0:82-0:606UB
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      CMR#(12);""="U1,100"C4"K";
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       PRINT CHRE(12);""X2,"Y2,"C6"65";
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           PRINT CHR8(12);""="C4"U001300";
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  65(1), 6P(1), N1(1), 1C(1,1)
                                                                                                                                                                                                                                                                                                                                                                                                                                                      ICO CLEARIDEFINT A.I.J.N.B.S.Z
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               PRINT CHR# (12) 7: G05UB 2100
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 58(1),5K(1),15(1),0(1)
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     PRINT"ENTER PROBLEM NAME"
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          140 IF LENGASING THEN 100
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       DIM MP(1), X(1), Y(1)
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           CHR*(12);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           PRINT
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            PRINT
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              SO PRINT
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  I I
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    240
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best available co
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'RECEIVE COORD PLUG FLAG FROM BITPAD: IGNOR IF FW IS NOT "4" OR "8" FOR BLUE AND GREEN BUTTON RESPECTIVELY INPUT#412.7.F#:IF FW="4" OR FW="8" THEN 1150 ELSE 1140
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              IGNOR NODE REQUEST IF DISTANCE IS < 5 DOTS
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   'IF BLUE BUTTON THEN ESTABLISH A NODE
                                                                                                                                                                                              NNIS)*(NNIZ)-NNII);/SIZ:NNIG)*(NNIG)*(NNIG))/41Z
PRINT CHR*(12);*"C4"U001450*;CHR*(7);:IF LEFT*(5*,1)<>*Y* THEN HT=5;GD5UB B50;GDTO 4100
PRINT*YGU WAYE FINISHED THE SCALING OF THE MAP. YOU ARE NOW READY TO INPUT THE*
PRINT *LOCATIONS OF*C6 ALL"C4 ROAD INTERSECTIONS*C6 AND ROAD END POINTS*C4 THAT EITHER:
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 ****THIS SECTION CONTROLS THE INPUT SIGNAL FROM THE 4 BUTTON CURSOR WITH DIGITIZER PAD
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    'REJECT COORD IF OUTSIDE SCALED AREA
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  'RECORD NODE COORD; PLOT ON SCREEN
                                                                                                                                                   INPUTATION TO FEET OR FEETS OR FEET OR FEET OR FEETS THEN NN(2) -XINN(5) -Y ELSE 600
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            IF GREEN BUTTON THEN DRAW AN ARC
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                LINE INPUT "CS"X003"Y005HIT RETURN TO CONTINUE.";Z4'PLAIN WAIT FOR CARRIAGE RETURN
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     CHR*(10);*TO DESIGNATE A POINT AS A NODE YOU NEED ONLY";
"POSITION THE CURSOR OVER IT AND PRESS THE "CIBLUE"C4 BUTTON. ";
"A BELL WILL SOUND INDICATING THAT THE NODE WAS ACCEPTED AND A"C1 BLUE"C4
"CIRCLE WILL MPPEAR ON THE SCREEN. "CGTAKE CARE TO ENTER AS MANY NODES ";
"MS YOU CAN IDENTIFY. ALL CONNECTING ROADS ";
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           ***THIS IS THE INFINATE LOOP SECTION TO WAIT FOR A LIGHT PEN HIT
TR=1:ON ERROR#1 GOTO 2000:DUTAMB0.0
PRINT CHR*(17)"GAI"CELIGHT PEN ACTIVATED"C7"K"
PRINT CHR*(10):CWR*(27):"GAO"K";
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        SCALE BITPAD COORD TO SCREEN
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            BRANCH TO DIGITIZER ROUTINE
"IF YOU SO ACT MEAR A BELL THEN YOU ARE OUTSIDE OF THE SENSITIVE AREA ON THE BITPAD. DECREASE THE SIZE OF THE AREA TO BE TRACED.";
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             'SET BITPAD A 10 COORD/SEC
                                                                                                                                                                                                                                                                                                                                                                                                             CMR*(10):"1) LENVE THE EDGE OF THE MREA THAT MAS SCALED EARLIER." CHR*(10):"2) TERMINATE AT ANY POINT INSIDE OF THE SCALED AREA."
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                REJECT INPUT IF ZERO
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          ++THIS SUBROUTINE PRINTS THE MENU AND SETS INITIAL HINDON CONDITIONS
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         ****THIS SUBROUTINE CHANG THE MACS BETWEEN THE MODES
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            ""U107060CHANGE "U107030SUPPLY/"U107020DENAND";
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          CMRs(27);"ON1"="H300,1005110,"R"G5";CHRs(12);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             "-U0540806TDP DR-U0610306AVE-U061020DATA";
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               ******** SUBROUTE : IN REMENTS THE NOTE COUNTER
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                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          *-25.50.10.07550.10,12550.10.17550.10,";
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                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                ""U204060515PLAY"U201030AMLY515";
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              "22550,10,27550,10,"L";CHR#(21);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         TR-1:GN ERROR#2 GOTO 2000:OUTAMBO,O
PRINT#4:"J":PRINT CHR6(27);"GNO";
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    "-U154080COMPUTE"U163030FLDW";
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          SAMPLEGEEUR LECCTIFF SHANG TARY LAACORTH CHREATTANTON - NEURING CHRE
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         ""DOI 6060AEE"UI, 030NOEE/ARC";
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                                                                                                            ": PRINT" - 7020"
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IF SM-25 THEN GOSUB 1400:SA-0:CL-NN.0; ELSE PRINT CHR*(7); 'ESTABLISH NODE IF DISTANCE > 25 DOTS PRINT ""I"K-F-CZ-G+";
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'IF HT<>1 THEN BRANCH TO APPROPRIATE SECTION
'GEARCH THROUGH MENU FOR CLOSEST POINT
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            **THIS SECTION CONTROLS THE BRANCHING TO THE APPROPRIATE SECTION AFTER A LIGHT PEN HIT ERR*Z* THEN ZOIO ELSE ON ERROR#O GOTO O
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               FIND DISTANCE TO CLOSEST NODE
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   SUM DISTANCE FROM LAST COORD
                                                                                                                'PLOT BLINKING GREEN CIRCLE
'PLOT CONCATENATED VECTOR
'REHEMBER OLD VALUES
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           IGNOR ALL LIGHT PEN HITS
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                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  DIVED THEM FAINT CHREATHION I GOTD 4100,4200,4300,4400,4500,4600
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                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     *+++THIS SUBPOUTINE FINDS THE CLOBEST NODE TO THE LIGHT PEN HIT
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     IF CLAID THEN PRINT USING "B":CL! ELSE PRINT USING "B#":CL! PRINT ""K"F"G+"::PLOT NX(CL).NY(CL),Z
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        GP nt GGTG 1040,855%,565%,5000,4100,4169
50=24;76% inl TG 6
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              IF SH=25 THEN GOSUB 1400:SH=0:CL=NN(0)
BU=6U+SH:PLOT NX(CL),NY(CL)
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      IF J2=S THEN 1716 ELSE 1716
DEG(J2)=DEG(J2)+1;NHRC(J2,DEG(J2))=L
IF J2=CL THEN 1718 ELSE 1720
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 DEGLUST-DEGGUZ)+1:NARC(UZ,DEGGUZ))=C
NEXT UZ
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                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           PRINT"F"CS+"::PLGT NX(S).NY(S).2
                                                                                                                                                                 PRINT "-2"LI"; PLOT NXICL; NYICL;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     PRINT ""U"::PLOT NAICL ; NYICL ;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          ****THIS SECTION CONTROLS THE
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    IN DIVER THEN SHADINGLAD
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                52.5.CL; =SU:52:CL, 5; =54:5U=0
                                                                                                                                                                                                           PLOT XP/YP:X0=XP:Y0=YP:S=CL
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      A1(L)=5:#2(L)=CL:C(L)=5U
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                                                                                                                                                                                                                                                                                                                                  DISMOSIXP-XD>+DBSIYP-YD)
IF DIVIOO THEN 1580
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                                                                                                                                                                                                                                                                                               CANADAMAN CHINESPAN AND CANADAMAN CONTRACTOR CONTRACTOR
                                                                                                                              PLOT NXICLIANISCLIAZ
                                                                                                                                                                                                                                                                                                                                                                                                                                                                6991 NBH 18447#1 1860
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                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     PRINT "L"; CHR8 (21);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   L-L+1: AN-L: NN: 21; -L
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          FOR J2-1 TO NN(16)
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                                                                                                                                                                                                                                                     IPPUTE 47.7. I.F.
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"C4"; DX(8,T)
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ERASE NY:DIM NY(MA):DOS"ARYLOAD "+A&+"NX NY"
IF NN:7) THEN ERASE SR.IS:DIM SR(NN:7)+1),IS(NN:7)+1);DOS"ARYLOAD "+A&+"BR BR":DOS"ARYLOAD "+A&+"IS IS" ELSE 2770
PRINT""CG";:FOR I=1 TO NN:7);CL=SR(1);GOSUB 1800:NEXT
IF NN:6) THEN ERASE SK:DIM BK(NN:8)+1);DOS"ARYLOAD "+A&+"SK BK" ELSE 2780
PRINT""CI";:FOR J=1 TO NN:6);CL=SK(J);GOSUB 1800;NEXT
                                                IF SKI OR SKINGS OR TKI OR TYNNGS THEN PRINT CHRO(12);"C4"IERROR ON INPUT"2"C7":GDTO 2300
PRINT CHRO(12);"C7THE PRESENT "C4"IONEWNY"2"C7 LENGTH OF THE DAC FROM NODE#"C3";S;""C7TO NODE#"C3";T;""C7TS;
PRINT""CGENTER THE NEW DISTANCE."
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             ***THIS SUBROUTINE COMPUTES THE LINKLIST DATA ARRAYS FROM THE D(1,1) MATRIX
                                                                                                                                                                                                                                                                                                           -CERETURN. -C4-J
                                                                                                                         INPUT "CTH CATTLES POTUTE MEDNE RESULTS IN NO CHANGE. "1"C5";DX(6,T)
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          DOB"REFRESH "+he:DOS"hRYLOND "+he+"NN NN";KY=NN(13);HA=NN(16)
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                PRINT CHRO(12);CHRO(7);"PROBLEM ";Ao;" NAS";NS(N+1);"ARCS."
                                                                                                                                                                                                                                                                                                                                                                                                                 ***THIS GUBSECTION SAVES BATA MITHGUT PROMPTING THE USER
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         "+14+"NARC NARC":DOB"ARYSAVE "+A4+"DEG DEG"
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   PRINT "NGW COMPUTING LINKLIST BATA ARRAYS FOR PROBLEM:
PRINT""C5"%002"Y002PLEASE WAIT"C7"X001"Y001"K"
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         '+++THIS SUBROUTINE RETRIEVES PREVIOUSLY SAVED DATA
                                                                                                                                                                                                                                                                                                                                                                                                                                        IF NN(7) THEN 2570 ELSE 2560
EGS"ARYSAVE "+A*+"SR SR":EGS"ARYSAVE "+A6+"IS IS"
IF NN(6) THEN 2550 ELSE 2600
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      "+De+"DI NI"LDOB"DRYSDUG "+De+"DL DL""DOB"DRYSDUG "+De+"DZ DZ"
                                                                                                                                                                                                                                                                                 PRINT "THIS IS THE FILE SAVE ROUTINE.":PRINT PRINT "TO SAVE DATH TIPE "CRITISTOPIZITO THEN LINE INPUT ZELLE IN A STOP" THEN 2520
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     PRINT""X2,"Y2,"CENDE BRUING BATA"X1,"Y1,";
GOS"RRYSBAUE "+Ne+"D BX":DOS"NRYSBAUE "+AE+"NS NS"
                                                                                                                                                                                                                                                                                                                                                          PRINT CARE(27); "GNO"="K"WO, 1005110, "; CHR6(12);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      RRANGE NG. NT. BL. BIM NG. MA+11. NT(G+MA). AL(G+MA)
PRINT CHRO(27); "CA1"; CHRO(12);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                FOR I'M TO NIFOR JOL TO N
IF DI(I,J)>0 THEN ADA+1:NT(A)=J:AL(A)=DX(I,J)
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         IF NN(7) OR NN(6) THEN DOS"ARYLGAD "+AS+"G G"
                         T-0:INPUT" CZENTER THE FINISH NODE #"CS";T
                                                                                                                                                                                                                                                              ****THIS SUBROUTINE SHVES THE DATH INPUT
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                DOB"DRYBAUE "+G++5K SK"
IF NN(7) OR NN(8) THEN DOB"ARYSAUE
NN(16)=RA:EOS"ARYSAUE "+A+*NN NN"
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       J:NS(I+1)-A:NEXT I
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                                                                                                                                                                                GOTO 2333
                                                                                                                                                    MA(13)=0
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-J-C5-120

Yes-Y or No-N

ARC LENGTH"C5"17"2"C7

SUBROUTINE ALLOWS FOR THE MANUAL CHANGING OF A SPECIFIC ARC LENGTH

LINE INPUT"-C760 YOU MANT TO CHANGE A SPECIFIC AN IF LETTS(15.1)<?\*Y" THEN 1420 ELSE PRINT CHRE(12); S=0:INPUT"-C7ENTER THE START NODE #-C5";S:PRINT

PRINT CHR\*(12);"-2";

2320

SIHL+++,

RETURN

```
ERASE DY.NX.NY:DIM DY.CM.MA.NA.NX.CMA)
IF NN(0) THEN PRINT""XZ,"YZ,"CGRETRIEVING DATA"XI,"YI,"K":DOG"ARYLOAD "+A0+"D DX" ELSE ERASE G:DIM GCMA):GOTO 4195
DOG"WRYLOAD "+N4+"NX NX":DOG"NRYLOAD "+N4+"NY NY"
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           Reproduced from best available copy.
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                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      ***THIS SECTION CONTROLS THE NEWD SELECTION FOR THE STOPPING OF PROGRAM EXECUTION PRINT CHRE(27);"ONL"K";CHRE(12);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    IF MN(8) THEN 4470
PRINT CHRS:12;;""C7YOU CAN NOT COMPUTE FLOM UNTIL THE NODES MAVE BEEN DESIGNATED.
                                                                                                                                                                                                                                                                                                     PAD"C5"17"2"C7 Yes=Y or No=N
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   PRINT"-CGYOU CAN NOT DISPLAY AN ANALYSIS UNTIL THE BUPPLY/DEHAND HAS BEEN
PRINT"YOU MUST "CSCHANGE SUPPLY/DEMAND"CG FIRST."
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              ****THIS SECTION CONTROLS THE NENU SELECTION FOR THE CALCULATION OF FLOW
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  ****THIS SECTION CONTROLS THE MENU SELECTION FOR THE DISPLAY OF ANALYBIS
PRINT CHR6(27);"ON1";CHR6(12);
                                                    ***THIS SECTION CONTROLS THE MENU SELECTION FOR THE BITPAD DATA INPUT
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                ****THIS SECTION CONTROLS THE MENU BELECTION FOR THE RESTART FUNCTION
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              ****THIS SECTION CONTROLS THE MENU SELECTION FOR THE INPUT OF DATA PRINT CHR*(27);"Ohi";CHR*(12);:GOSUB 3000
PRINT CHR*(12);""X2,"Y2,"CBSAVING DATA"X1,"Y1,"K":GOSUB 2550
PRINT CHR*(12);""K"C2";\L DATA HAS NOW BEEN ENTERED."2"C7*
HT*!:IF TR THEN DUT&HBO,O:RESUME 1020 ELSE TR*!:GOTO 1000
                                                                                                                                                                                                                                                                                                                                                       HT=6:PRINT CHR*(12);"-C2DIGITIZER ACTIVATED"K";CHR*(7);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      MI*1:1F IR THEN BUTANSO, O:RESUME 1020 ELSE GOTO 1000
                                                                                                                                                                                                                                                                                                                                                                                                                                             DGS"PICTURE "+14:17(10)=0:DGS"12/SDVE "+14+"NN NN"
DGS"12/YSDVE "+14+"NX NX":DGS"ARYSDVE "+16+"NY NY"
GGSUG 860:GGSUB 1000:PRINT CHR*(12);
                                                                                                                                                                                                                                                                                                                                                                                         IF NN($) THEN GUTAMSO, $: RESUME 1100 ELSE GOTO 1100
                                                                                                                                                                                                                                                                                                     LINE INPUT""C750 YOU WANT TO USE THE DIGITIZER IF LEFTS(ZS.1)
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          PRINT CHRG(27); "Oh! "!CHRG(12);
PRINT" "C7#"C51"C7" ("CGCOMPLETE RESTART"C7, ("
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           PRINT"MUST "CSCHANGE SUPPLY/DEMAND"C7 FIRST."
                                                                                                                                                                                                                                                                                                                                                                                                                      PRINTCHR#(27); "DAO"K"WG, 1005110, "; CHR$(12);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            RINT "C78"C52"C7" "C6MAJOR RESTART"C7. ""
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        GOSUB 2300:PRINT" = "; CHR6(12);:CLEAR:END
                                                                                                           DEF PREVIVE STRUCK-NACED / NACED+ . S)+100
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         PRINT "XZ, "YZ, "C2PLEASE WAIT"X1, "Y1,";
                                                                                 DEN FREKLYJEFIKELK-NN(1))/NN(G)+.G)
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               PRINT CHR6(27);"041"K";CHR6(12);
                                                                                                                                                                PRINT CHRE(27); "DA1"; CHRE(12);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      PRINT "C70 C53 C7 - ' "CBMINGR
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    IF NN(7) AND NN(8) THEN 4560
                                                                                                                                                                                                                                                                           GOSUB 2300: PRINT CHR4 (12);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    GUT AMBO.O:RESUME 4480
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RETURN

APPENDIX C

PROGRAM SOLVE

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PRINT" CSMOW MANY NODES WILL BE IN PROBLEM 44 "JAG!" CSTJ": MA"O: INPUT MA
IF MALL OR MAJGO THEN 42 ELBE MALLE) = MACE INCIDENT TO CHE (12);
PRINT" CS THE LIMIT OF THE NUMBER OF MACE INCIDENT TO CHE NODE IS 20"
PRINT" CSHWAT IS THE MALLIMM IN PROBLEM C4 "JAG!" CSTJ": MB=0: INPUT MB
IF MGLI OR MB>20 THEN 45 ELBE NA(15)=MB:PRINT" UCCOCSE"
PRINT" C5 THE LIMIT ON THE TOTAL NUMBER OF MRCE IS 1200"
PRINT" CSHOW MANY FRCE MRE IN PROBLEM C4 "JAG!" CSTJ": MC=0: INPUT MC
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          100 BIM DINC+11.-DZ(NC+1):EGS"ARYLDAD "+A8+"A1 A1":EGS"ARYLDAD "+A8+"A2 A2"
103 BIM BEG(NB+1):NARC((NA+1):(NB+1))
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         AL(3)= NODE 1 OF ARC J

"AL(3)= NODE 1 OF ARC J

"CL3= COST OF MRC J

"CL3= COST OF MRC J

"IN(K, J)= 1 IF MRC J MUST BE A MEMBER OF THE KTH TREE; O OTHERWISE

"BET(K, J)= 1 IF MODE 1 IS CONNECTED TO THE KTH TREE; O OTHERWISE

"EEG(1)= DEGREE OF MODE 1
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             MA ELEMENT OF THE KTH TREE; & OTHERNISE
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       ***THIS SUBPOUTINE SOLVES THE K MINIMUM MEIGHT SPANNING TREES
                                                                                                                                                                                                                                                                                                  ALCOM 18 60"
                                 THE JTH ARC CONNECTING NODE
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  110 EGS"ARYLGAG "+ns+"DEG DEG":DGS"ARYLGAD "+As+"NARC NARC"
115 bim c(MC+1):EGS"ARYLGAG "+As+"C C"
                                                                                                                         CLEGASTEFINT A.B.C.D.F.N.M.6.O.I.J.K.L
BIN NN(30), AB(10.100).IN(10.100).GU(10.100).EET(5.60)
BIN FRN(60).CD(5).BI(5).BO(5)
PRINT CHRO(12):"X2,"Y2,"CB"88";
PRINT CHRO(12):"X2,"Y2,"CB"88";
PRINT ENTER PROBLEM NAME" ":Ns
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                'KMAX' MINGER OF HINIMUM WEIGHT TREES DESIRED
'CD(K): AINIMUM WEIGHT REPLACEMENT FOR THE KTH TREE
'BI(L): GEST INCOMING REPLACEMENT FOR THE KTH TREE
'GO(K): GEST OUTGOING REPLACEMENT FOR THE KTH TREE
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       BO PRINT=""K":CHR6(12);
ED BOS"REFRESH "+AG:BOS"ARYLOAD "+AG+"NN NN":NY=NN(13)
BO BIM NX(MA):BOS"ARYLOAD "+AG+"NX NX"
GO BIM NY(MA):GOS"ARYLOAD "+AG+"NY NY"
                                                                                                                                                                                                                                                                                                                                                                                                                                                               IF MC<0 GR MC>1200 THEN 48 ELSE NN(21)=MC

**** THIS SECTION REIRIEUES THE NETWORK AND DATA

PRINT="="""(")CMR6(12);
                                                                                                                                                                                                                                                                                                  MODES NEMORY MILL
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              'ATH THE HIGHEST NUMBER KIN TREE
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               DIM DEGIME+1; MARCICIM+1; (MB+1))
                                                                                                                                                                                                                                                                                                PRINT" CETHE NAXIMUM NUMBER OF
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'MARC(1,1) = DESIGNATION
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             PRINT "CSHOW MANY MINIMUM WEIGHT TREES WOULD YOU LIKE TO SEE? (5 OR LESS)";:ND-0:INPUT MD
                                                                                                                                                                                                                     FOR J=1 TO M:IN(KTH,J)=IN(TEMP.J):OU(KTH,J)=OU(TEMP.J):AB(KTH,J)=AB(TEMP.J):NEXT
OU(KTH.BO(TEMP))=1:AB(KTH,BO(TEMP))=O:IN(TEMP.BO(TEMP))=1:AB(KTH,BI(TEMP))=1
                                                                                                                                                                                                                                                          PRINT "C2 THE KITH MINIMUM MEIGHT SPANNING TREE FOR K. "IKTH
                                                                                                                                                                                                                                                                                                                                                                                                               ?:
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   (SET(E, A)(A);+SET(E, A2(A)))=1 THEN SPT+SPT+1 ELSE 6630 C(A)<CN THEN CN-C(A):NEXARC=A ELSE 6630
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        'THIS SUBSECTION SOLVES THE MINIMUM MEIGHT BPANNING THEE
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IF KTM*KH THEN 6245
K*TEMP:GOSUB 6600
                                                                                                                                                                                                                                                                                                               C057
                                                                                                                                                                                       IF CD(1) CHI THEN HISCO(1):TEMP=1:NEXT
                           F MEXI OR MEN THEN GOTS ELSE KN-ME
                                                                                                                                                                                                                                                                                                             NODE#2
                                                      FOR UP1 TO MI INCK, J) = 01 OU(K, J) = 0
                                                                                                                  Kelikthelinensedisptedissus 6500
If Krel Ther 6880 ELSE GOSUS 6600
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                IF SET(K, 1) -1 THEN 6500 ELSE 6640
                                                                                                                                                                                                                                                                                                               MODERAL
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                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                MEXARC=0:FOR 1=1 TO N
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   FOR IL-1 TO DEG(I)
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                                                                                                                                                                                                                                                                                                             SP inc
PRINT CHESKIZE
                                                                                                                                                                     FOR 1-1 TO KTH
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      PRINT "SUMMAY"
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                                                 10 KM
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                                                                                                                                                                                                       KTH-KTH+1
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                                                 198 K-1
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51=C:J)-C(ARC)
IF IN!K,ARC)=0 THEN IF DICMN THEN MH=DI[C]=J[C]=ARC ELSE 6805 ELSE 6805
IF MH=0 THEN 6865
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        FOR I=1 TO DEG(KI): TEMP=WARC(KI,I):
IF AG(K,TEMP)=1 TWEN MENS=MENS+1 ELSE 8060
IF AL(TEMP)=FRM(KI) TWEN IF AZ(TEMP)=HI TWEN 6035
IF AZ(TEMP)=FRM(KI) TWEN IF AL(TEMP)=KI TWEN 6035 ELSE 6060 ELSE 6060
                                                                                                                                                                                                                                                                                                          ?:
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   IF AS(R.J)=0 THEN IF QU(R.J)=0 THEN GOZO ELSE GOGZ ELSE GOGZ
FOR I=1 TO N: FRM(1)=0:NEXT
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         IF IN(K,TEMP)=0 THEN IF DI<PM THEN 6845 ELSE 6855 ELSE 6855 HEAS==EAS+1:NH=DI:CI=J:CT=TEMP
                                                                                                                                                                                                                                                                                                          *:(()):•
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        CD(K)=Mk+CD:BI(K)=CI:BD(K)=CT
PRINT="C6 CD= ";CD(K);" B1= ";BI(K);" B0= ";BO(K);"*C1=
PRINT "KIN= ";KIN;" TEMP= ";TEMP
         AAC#
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                IF FRM(1) <>> THEN 6845 ELSE 6885
FOR L=1 TO DEG(1): ARC=NAPC(1,L)
IF AG(K,ARC)=1 THEN 6848 ELSE 6875
IF FRM(AL(ARC))>O THEN IF FRM(AZ(ARC))>O THEN 6875
IF AL(ARC)=1 THEN 6855 ELSE 6880
                                                                                                                                                                                                                                                                                                                                                           MENT J
PRINT"—CATME COST OF THE SPANNING TREE IS "CI";CO
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              THIS SUBSECTION COMPUTES THE BEST ARC EXCHANGE
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      ALCARCIONI THEN KICALCHE ELSE KICARCI
                                                                                                                                                                                                                                 DESTRUCTION THEN BELLEGISCO-CO-COOK ELSE 6770 PARTY PA
    C05T
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  MEAS-MEAS+2:FRH(A2(ARC))-I: GOTO 6665
         NODE #2
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                F FRMIK11-H2 THEN 6862 ELSE 6810
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 #5(K,JZ)#1 THEN CO=CO+C(JZ)
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              H1=61(J):H2=42(J):FRN(H2)=H1
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             ENS-MENS+2:FRM(N1(NRC))=1
         NODE#1
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             ALCARCISH THEN GBBO
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# APPENDIX D

POWER PLANT AND POWER LINE TEAMS

### Appendix D-1

### g. Team HG, Power Plan Operation and Maintenance

- (1) Capabilities. Operates and maintains installed electrical power plants of at least 900 KW capacity, of up to 3 generators having combined capacity of 900 to 7,500 KW capacity.
- (2) Basis of Allocation. One per electric power generating plant of 900 to 7,500 KW capacity.
  - (3) Mobility.
- (a) This unit is authorized by TOE 16 personnel and approximately 1,900 pounds (100 cubic feet) of equipment requiring transportation. Non-equipment and supplies constitute approximately 1,200 pounds (50 cubic feet).
- (b) On a move to a new location using one lift by organic assets, the unit can move approximately two personnel and 1,500 pounds (150 cubic feet) $\underline{1}$ / of equipment and supplies.

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1	mress		TORCH OUTPLY CUTTING MIG VELD INGE SET 2	65	1 1			1		
I	-		TRUCK CARGO: TACTICAL L-4 /4 TON 4E2 H/E	•3	3					

## 1. Team HI, Power Line

- (1) Capabilities. Installs and maintains up to 60 miles of high voltage electrical power lines.
- (2) Basis of Allocation. One per two electric power generating plants of 900 to 7,500 KW capacity. Normally attached to an Engineer Facilities Engineer Group, TOE 5-203.

### (3) Mobility.

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- (a) This unit is authorized by TOE 14 personnel and approximatley 7,200 pounds (950 cubic feet) of equipment requiring transportation. Non-TOE equipment and supplies constitute approximately 1,000 pounds (50 cubic feet).
- (b) On a move to a new location using one lift by organic assets, the unit can move approximately 14 personnel and 7,540 pounds (730 cubic feet) $\underline{1}$ / of equipment and supplies.

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